OLLSCOIL na hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY of IRELAND, GALWAY

SUMMER EXAMINATIONS 2005 – HONOURS

B.Sc. (Part II) Examination

MA410 – Artificial Intelligence

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Time allowed: *two* hours
Full marks for *three* questions

1. (a) Let S denote the compound proposition $(\overline{p} \to q) \to (p \to \overline{q})$. Find the truth table and a *conjunctive* normal form for S. Hence, or otherwise, show that the argument $q, S \therefore \overline{p}$ is valid.
   (b) A variant of Nim starts with several piles of tokens, and the two players take turns to move. A move consists of taking an *odd* number of tokens from *exactly one* pile, and the player taking the last token *loses*.
   Draw the complete game tree (or graph) starting from
   (i) 4 (ii) 5 (iii) (3,3)
   and use *minimax* to decide the winner in each case.
   What can you say about this game in general?

2. The predicates $A(x,y), P(x,y)$ and $S(x,y)$ could be interpreted by "x is an *a*unt / *p*arent / *s*ister (respectively) of y". Write sentences H_1, H_2, H_3 and C in the predicate calculus so that: H_1 defines A in terms of P and S; H_2 says everyone has a parent; H_3 says everyone has a sister; C says everyone has an aunt. Convert each of H_1, H_2, H_3 and $\overline{C}$ to clause form, and use resolution to show that C follows logically from H_1, H_2, H_3.

3. Consider a puzzle consisting of four tiles, two labelled by 'B' and two labelled by 'W' together with an empty space in the following configuration:

The tiles can be moved according to the following rules.

- The tiles labelled by 'B' can only be moved to the left.
- The tiles labelled by 'W' can only be moved to the right.
- A tile can be moved into an adjacent empty space.
- A tile can jump over one tile with a different label.

The goal is to achieve the following configuration:

(a) Use the depth first search algorithm to solve this puzzle.

(b) Define a suitable heuristic $h(X)$ and use the best first search algorithm with the evaluation function $f(X) = g(X) + h(X)$ to solve this puzzle.

(c) Define what is meant by 'Algorithm A^*'. With your definition of $h(X)$, is your algorithm A^*?

(d) What is the definition for a heuristic function to be *monotone*? Is your $h(X)$ monotone?

4. (a) Define a Prolog predicate `same_length` such that `same_length(X,Y)` succeeds if `X` and `Y` are lists with the same number of elements.

(b) Define a Prolog predicate `subseq` such that `subseq(X,Y)` succeeds if the list `X` can be obtained by deleting $n \geq 0$ elements of `Y`. For example

```
subseq([n,u,i,g], [e,n,d,u,r,i,n,g])
```

should succeed, whereas

```
subseq([n,u,i,g], [g,u,i,n,n,e,s,s])
```

should fail.

(c) Using your definition from (b), show that `subseq([n,u,i,g], [e,n,d,u,r,i,n,g])` succeeds, and that `subseq([n,u,i,g], [g,u,i,n,n,e,s,s])` fails.